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(54) Title of the Invention: Bank Note Discriminating Device

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Specification

Title of the Invention Bank Note Discriminating Device

Claims

1. A bank note discriminating device for scanning an optical pattern on a bank note to be identified using an optical means and determining the denomination of the bank note based on the detected signals, wherein the bank note discriminating device is equipped with (a) a photoelectric detector with a light source and a light-receiving element and having a detection surface that is short in the scanning direction and long in the direction perpendicular to the scanning direction, (b) a waveform converting circuit for changing the waveform of the output from the photoelectric detector, (c) a comparison circuit for comparing the output from the waveform converting circuit to a plurality of preset levels, (d) a position determining circuit for determining the scanning position by counting the scanning timing signals outputted simultaneously with the scanning, (e) a memory circuit for storing the output from the comparison circuit at the position indicated by the position determining circuit, and (f) a logic operation circuit for determining the denomination of the bank note based on the output from the memory circuit.

2. The bank note discriminating device in Claim 1, wherein the waveform converting circuit has a differentiating circuit for differentiating the waveform of the output from the

photoelectric detector, and a squaring circuit for squaring the output from the differentiating circuit.

3. The bank note discriminating device in Claim 1, wherein the position determining circuit has a counting circuit for counting the scanning timing signals and a zone forming circuit for using the count signals from the counting circuit to form signals for dividing the scanned zone of the bank note into a plurality of zones, and wherein the levels of each zone are compared.

4. A bank note discriminating device for scanning an optical pattern on a bank note to be identified using an optical means and determining the denomination of the bank note based on the detected signals, wherein the bank note discriminating device is equipped with (a) a photoelectric detector with a light source and a light-receiving element and having a detection surface that is short in the scanning direction and long in the direction perpendicular to the scanning direction, (b) a waveform shaping circuit for shaping the waveform of the output from the photoelectric detector, and (c) a time interval circuit for determining the amount of time an output from the waveform shaping circuit is to be maintained at a certain level and outputting a signal when a preset period of time has elapsed.

Detailed Description of the Invention

The present invention relates to a bank note discriminating device and, more specifically, to a bank note discriminating device for counting bank notes, identifying the

denomination of ach bank note, sorting the bank notes by denomination in a storage area or discharging the bank notes by denomination.

Bank note discriminating devices are usually equipped with a plurality of check points. The transit of the bank notes is strictly controlled so they pass correctly over the check points and the detectors can determine the denomination of the bank notes. The processing speed is slowed to allow for greater positional control, but bank note counters and bank note sorters are capable of much higher speeds. Therefore, the purpose of the present invention is to provide a bank note discriminating device that can solve this problem.

The following is an explanation of the present invention.

The present invention is a bank note discriminating device for scanning an optical pattern on a bank note to be identified using an optical means and determining the denomination of the bank note based on the detected signals. Here, the bank note discriminating device is equipped with a photoelectric detector with a light source and a light-receiving element and having a detection surface that is short in the scanning direction and long in the direction perpendicular to the scanning direction, a waveform converting circuit for changing the waveform of the output from the photoelectric detector, a comparison circuit for comparing the output from the waveform converting circuit to a plurality of preset levels, a position determining circuit for determining the scanning position by counting the scanning timing signals outputted simultaneously with the scanning, a memory circuit for storing the output from the comparison circuit at the position indicated by the position determining circuit, and a logic operation circuit for

determining the denomination of the bank note based on the output from the memory circuit. The bank note discriminating device of the present invention can als be equipped with a photoelectric detector with a light source and a light-receiving element and having a detection surface that is short in the scanning direction and long in the direction perpendicular to the scanning direction, a waveform shaping circuit for shaping the waveform of the output from the photoelectric detector, and a time interval circuit for determining the amount of time an output from the waveform shaping circuit is to be maintained at a certain level and outputting a signal when a preset period of time has elapsed.

The following is an explanation of a working example of the present invention with reference to the drawings.

FIG 1 shows the conveyor mechanism for bank notes. Bank notes 1 inserted for denomination identification and conveyed on the conveyor belt 2 are separated into individual bank notes by a separating roller 3 rotating in the opposite direction of the conveyance direction and then sent to conveyor roller 4. The bank notes taken up by conveyor roller 4 are subsequently taken up by conveyor belt 5 and conveyor roller 6 so as to be conveyed in the upward direction in the drawing. The bank note arranging roller 7 at the exit places the bank notes in a housing unit 8. A light source 9 and a light-receiving element 10 are arranged opposite each other with the section of the conveyor system consisting of the conveyor belt 5 and the conveyor roller 6 interposed between them. A more detailed view can be found in FIG 2. The highest position on the conveyor belt 5 for conveying bank notes 1 has a light-blocking plate 12 with a slit 11 that is short in the conveyance direction of the bank notes 1 and long in the direction

perpendicular to the conveyance direction. The light source 9 such as a lamp and the light-receiving element 10 such as a photodiode are arranged opposite each other with the slit 11 in the light-blocking plate 12 interposed between them. A rotary encoder 13 is situated at the rotation section of the conveyor belt 5, and the output from the rotary encoder 13 and the light-receiving element 10 are processed by the circuit shown in FIG 3.

In FIG 3, the amount of light detected by the light-receiving element 10 from the light source 9 is converted to a corresponding amount of electric current, and the electric signals are converted to voltage signals V by the current-voltage signal converter 20 and inputted to inverter 21 and comparator 22. The voltage signals $\underline{V}$ inverted by inverter 21 are amplified by the non-inverting amplifier 23, and the amplified signals VF are inputted to the differentiating circuit 24 and comparator 25. The output DV from the differentiating circuit 24 is inputted to the squaring circuit 26 and squared. The output SV therefrom is inputted to two comparators 27, 28 with different comparative levels, and the results of the comparison P, Q are inputted to AND circuits 29 ~ 31 and 32 ~ 34, respectively. The output CV from the comparator 25 is inputted to AND circuit 36 via inverter 35, and the output CM from comparator 22 is inputted to AND circuit 36 and counter circuit 37. The turning on and off of the analog switch 41 is controlled by the output G from the AND circuit 36, the voltage from the voltage device 38 is integrated by the linear sweep device 39, and the integrated value NR is inputted to the comparator 40. The output pulse CP from the rotary encoder 13 is counted by the counter circuit 39, and the count value is inputted to a zone forming circuit 50 consisting of logic circuits 50A ~ 50C. The zone-divided zone signals Z1, Z2, Z3 are inputted to AND circuits 29 and 32, AND circuits 30 and 33, and AND circuits 31 and

34, respectively. The output from AND circuits 29 ~ 34 are inputted to flip-flops 51 ~ 56, and the output therefrom is outputted to latched circuits 58 ~ 63. The output CA from comparator 40 is also inputted to latched circuit 64 via flip-flop 57. The data latched by latched circuits 58 ~ 64 are inputted all at once to logic operation circuit 65 using a strobe pulse SP.

In this configuration, the conveyed bank notes 1 are separated from each other by the operation of the conveyor belt 2 and a separating roller 3, are conveyed to the bank note arranging roller 7 by the conveyor belt 5 and conveyor roller 6 via conveyor roller 4, and are placed successively in a storage unit 8. In this case, the output pulses CP from the rotary encoder 13 are inputted to the counter circuit 37. This operation is described below.

A bank note conveyed by the conveyor belt 5 and the conveyor roller 6 is scanned by the light passing through the slit 11 in the plate 12 from the light source 9, which reaches the light-receiving element 10. The light-receiving element 10 outputs an electric current signal corresponding to the amount of light received, and this signal is converted to a voltage signal by the current-voltage signal converter 20. The voltage signal V is inputted to inverter 21 and comparator 22 as shown in FIG 4 (A). If the reference voltage in comparator 22 is V1, the output CM as shown in FIG 4 (B) is "1" at time t0 and tf where signal V is lower than reference voltage V1. This is inputted to the AND circuit 36 as the master pulse and inputted to the counter circuit 37 as the count enable signal. In other words, the counter circuit 37 counts the pulses CP outputted from the rotary encoder 13 when CM is "1". The reference voltage V1 in comparator 22 is linked to voltage signal V and set to correspond to the bank note on top of the slit 11.

The voltage signal V from the current-voltage signal converter 20 is inverted by the inverter 21, and the inverted voltage signal $\underline{V}$ is inputted to the non-inverting amplifier 23. The non-inverting amplifier 23 adds a positive direct current bias voltage BD to the negative voltage signal $\underline{V}$, amplifies only the position portion of the voltage signal, and sends the amplified signal to the differentiating circuit 24 and the comparator 25. In other words, the output $\underline{V}$ from the inverter 21 is negative voltage that is the inverse of the voltage signal V shown in FIG 4 (C). This is inputted to the non-inverting amplifier 23. The non-inverting amplifier 23 adds a positive direct current bias voltage BD to the negative voltage signal $\underline{V}$. Here, the bias voltage BD added to the voltage has to make it positive between time t0 and tf. The voltage signal made positive by the addition of the positive direct current bias voltage BD between t1 and t2 is amplified and the amplified signal VF shown in FIG 4 (D) can be obtained. The actual voltage signals VF for 10,000-yen notes, 5,000-yen notes, 1,000-yen notes and 500-yen notes are shown in FIG 5 (A) through (D), respectively. As shown in this figure, the output for the 10,000-yen note is essentially "0". An voltage output CV from comparator 25 with a reference voltage of nearly "0" indicates a 10,000-yen note as shown in FIG 4 (E). Because this is inputted to AND circuit 36 via inverter 35, the AND circuit 36 obtains the output G shown in FIG 4 (F). When the output G from AND circuit 36 is "1", analog switch 41 is turned on and the linear sweep device 39 is activated. In other words, the output is integrated in linear fashion and outputted when the direct current voltage supplied by the voltage device 38 is positive. When the output G is "0", the analog switch 41 is turned off and the linear sweep device 39 is cleared. As a result, the sweep output NR from the linear sweep device 39 has a saw-tooth shape as shown in FIG 4 (G). Because the sweep output NP is inputted to the comparator 40 and compared to the reference voltage V2, the signal CA shown in FIG 4 (H) is outputted at

time t3, flip-flop 57 is set, and the set output is inputted to the latched circuit 64. As shown in FIG 5, the bank notes other than 10,000-yen notes do not generate an amplified output VF of "0" when scanned. Over the course of the relatively long scanning period for 10,000-yen notes (equivalent to time t4 to time t3 in FIG 4), the analog switch 41 is not turned on and no signal CA is outputted. In other words, signal CA is outputted for 10,000-yen notes and latched by the latched circuit 64. Here, linear sweep device 39 and the other circuits were used to obtain signal CA. However, the time can also be measured during which the amplified output VF or output CV from the comparator 25 is held at the low level (nearly "0"), and a time limit circuit used to output signal CA after a predetermined amount of time has elapsed.

In the case of 10,000-yen notes, a signal CA is obtained. The following is a description of the process for the other bank notes.

Here, the amplified signal VF from the non-inverting amplifier 23 is differentiated by the differentiating circuit 24, the signal DV is squared by the squaring circuit 26, and the squared signal SV is inputted to comparator 27 and comparator 28. Comparator 27 compares the signal to a relatively high reference voltage V3 and comparator 28 compares the signal to a relatively low reference voltage V4. If the squared voltage SV exceeds voltage V3, comparator 27 outputs a "1" signal. If the squared voltage SV exceeds voltage V4, comparator 28 outputs a "1" signal. For example, if the differentiating signal DV shown in FIG 4 (I) is outputted from the differentiating circuit 24, it is squared by the squaring circuit 26 an the squared signal SV shown in FIG 4 (J) is outputted. If reference voltage V3 and reference voltage V4 are set as shown in FIG 4 (J), the output P from comparator 27 and the output Q from comparator 28 are shown

in FIG 4 (K) and FIG 4 (L), respectively. Here, the actual squared outputs for the various bank notes are shown in FIG 6 (A) through FIG 6 (H). FIG 6 (A) and FIG 6 (B) show the squared signals for a 10,000-yen note. FIG 6 (C) shows the squared signals for a 5,000-yen note. FIG 6 (D) through FIG 6 (F) show the squared signals for a 1,000-yen note. FIG 6 (G) and FIG 6 (H) show the squared signals for a 500-yen note. The squared signals SV for the various bank notes are inputted to comparator 27 and comparator 28. Comparator 27 compares the signal to a relatively high reference voltage V3 and inputs output P to AND circuits 29 ~ 31, and comparator 28 compares the signal to a relatively low reference voltage V4 and inputs output Q to AND circuits 32 ~ 34.

When the rotary encoder 13 is activated by the counter, the conveyor belt 5 begins to move, the pulse signal CP shown in FIG 4 (M) is outputted, and the signal is inputted to the counter circuit 37. Because the output CM from converter 22 is "1" at time t0, the counter circuit 37 begins by counting pulse signal CP, and the output therefrom is inputted to the zone forming circuit 50 consisting of logic circuits 50A ~ 50C. The zone forming circuit 50 outputs three zone signals Z1, Z2, Z3 based on the numeric values from the counter circuit 37, and outputs zone signal Z1 to AND circuits 29 and 32, zone signal Z2 to AND circuits 30 and 33, and zone signal Z3 to AND circuits 31 and 34. As shown in FIG 4 (N) through FIG 4 (S), zone signal Z1 is outputted at times t0 through t5, zone signal Z2 is outputted at times t5 through t6, and zone signal Z3 is outputted at times t6 through tf. When signal P is outputted by comparator 27 and when signal Q is outputted by comparator 28 between t0 through t5, t5 through t6 and t6 through tf, a "1" signal is outputted from AND circuits 20 through 34 only if zone signals Z1, Z2 an Z3 are "1", and flip-flops 51 through 56 are set. Here, a zone signal Z1 of "1" indicates

Zone I, a zone signal Z2 of "1" indicates Zone II, and a zone signal Z3 of "1" indicates Zone III. The setting-setting outputs consisting of an H level (comparator 27) and an L level (comparator 28) for the various bank notes are shown in FIG 7. In Zone I through Zone III, a 10,000-yen note will have an H level of "101" and an L level of "111" as shown in FIG 6 (A) or an H level of "101" and an L level of "101" as shown in FIG 6 (B). A 5,000-yen note will have an H level of "101" and an L level of "101" as shown in FIG 6 (C). A 1,000-yen note will have an H level of "001" and an L level of "111" as shown in FIG 6 (D), an H level of "100" and an L level of "111" as shown in FIG 6 (E), or an H level of "000" and an L level of "111" as shown in FIG 6 (F). A 500-yen note will have an H level of "101" and an L level of "111" as shown in FIG 6 (G) or an H level of "111" and an L level of "111" as shown in FIG 6 (H). Because the logical output for the various denominations can be set for Zone I, Zone II and Zone III, the actual data for the H levels and L levels can be combined with the actual data from FIG 6 in FIG 7. The zone does not have to be divided into thirds. It can also be divided into fifths.

The signals set by the flip-flops 51 ~ 57 are transferred to the latched circuits 58 ~ 64 all at once, and the latched outputs are transferred all at once to the logic operation circuit 65 by the input of a strobe pulse SP. The logic operation circuit 65 then determines the denomination of a bank note using the logic signals in FIG 7, and outputs a denomination signal. Here, the signal CA inputted from the comparator 40 is recognized as a 1,000-yen bank note signal. A denomination signal is outputted without using the output P, Q from the comparators 27, 28 for determining the denomination.

In the present invention, the detection surface is short in the scanning direction and long in the direction perpendicular to the scanning direction. Also, the bank note zone is divided into three zones and the squared output from each zone is compared at two levels (high and low) to generate discrimination signals. As a result, the bank notes do not have to be positioned precisely and a larger number of bank notes can be processed at higher speeds.

In the working example, the light source and the light-receiving element were stationary and the bank notes were transported and scanned. However, the present invention can also be configured so the bank notes remain stationary and the light source and light-receiving element move and scan the bank notes.

Brief Explanation of the Drawings

FIG 1 is a drawing of the mechanism in a bank note counter used in the present invention.

FIG 2 is a simplified drawing of the optical scanner therein.

FIG 3 is a drawing of a circuit used in the present invention.

FIG 4 is a timing chart in which (A) through (S) are operational examples.

FIG 5 is a waveform diagram of amplified signals (A) through (D) outputted for the different denomination bank notes.

FIG 6 is a waveform diagram of signals (A) through (H) in which differentiating signals outputted for the different denomination bank notes have been squared.

FIG 7 is a table showing the binary value relationship between the H level and the L level in Zone I, Zone II and Zone III for the different denomination bank notes.

1 ... bank note

2, 5 ... conveyor belts

3 ... separating roller

4, 6 ... conveyor rollers

7 ... bank note arranging roller

8 ... storage unit

9 ... light source

10 ... light-receiving element

11 ... slit

12 ... plate

13 ... rotary encoder

20 ... current-voltage signal converter

21, 35 ... inverters

22, 25, 27, 28, 40 ... comparators

23 ... non-inverting amplifier

24 ... differentiating circuit

26 ... squaring circuit

29 ~ 34, 36 ... AND circuit

37 ... counter circuit

38 ... voltage device

39 ... linear sweep device

41 ... analog switch

50 ... zone forming circuit

50A ~ 50C ... logic circuits

51 ~ 57 ... flip-flops

58 ~ 64 ... latched circuits

65 ... logic operation circuit

FIG 1

FIG 2

FIG 3

10 ... Light Passes Through

65 ... 10,000 5,000 1,000 500

FIG 4

FIG 5

FIG 6

FIG 7

	H Level			L Level		
	I	II	III	I	II	III
10,000 Yen Note	1	0	1	1	1	1
	1	0	1	1	0	1
5,000 Yen Note	1	0	1	1	0	1
1,000 Yen Note	1	0	0	1	1	1
	0	0	1	1	1	1
	0	0	0	1	1	1
500 Yen Note	1	0	1	1	1	1
	1	1	1	1	1	1